National Aeronautics and Space Administration

Materials and Coatings

High Temperature Liquid Crystal Thermosets

New polymer chemistries benefit processing and performance

NASA's Langley Research Center has a family of chemistries and supporting patents for improved liquid crystalline polymers (LCPs). The NASA materials use low-melting, all-aromatic ester-based liquid crystal oligomers end-capped with reactive phenylethynyl end groups. This reactive oligomer approach enables synthesis of liquid crystal thermosets with outstanding mechanical and thermal properties that are superior to wellknown high-performance polymers such as PPS and PEEK.
NASA's chemistries offer inexpensive and adaptable materials for melt processing complex shapes using resin transfer molding or resin film infusion techniques. The low coefficient of expansion, combined with excellent barrier properties, makes this new technology useful for cryogenic and other extreme temperature applications. The excellent barrier properties provide chemical resistant to acids, bleaches, chlorinated solvents, alcohols, and hydrocarbon fuels.

BENEFITS

- A much broader process window than typical LCPs

  -- End groups are stable in the melt up to 300C (1 hour), which gives ample time for processing

- Inexpensive - uses commercially available monomers and standard melt polymerization techniques

- Improved mechanical properties and thermal stability (Tg>250C, Tdec~500C)

  -- Final product remains in its liquid crystalline state after curing, which enables improved chemical resistance and excellent barrier properties to small molecules

  -- The low CTE and amorphous nature will allow for the fabrication of thick structures without internal stresses

  -- Low melt viscosity

  -- Low dielectric constant

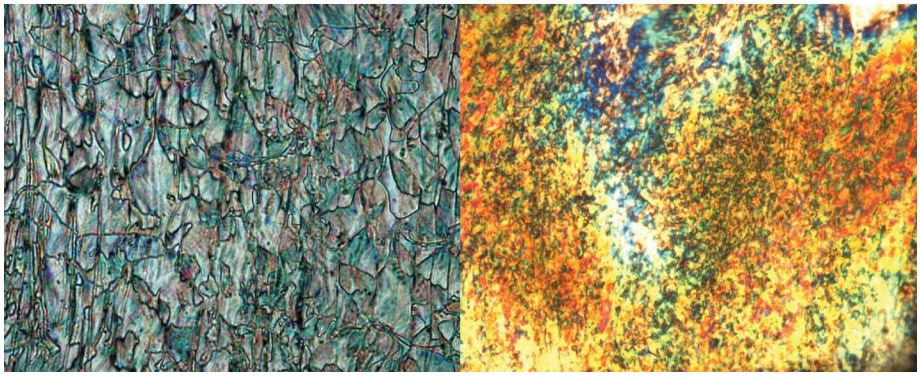
- Flame retardancy and low smoke generation - these resins typically have a UL94 VO rating

- Good adhesive properties

technology solution

THE TECHNOLOGY

Depending on the backbone chemistry and the molecular weight (controlled by reactive end group concentration), NASA has developed various liquid crystalline resins (LCRs) with a wide range of physical and chemical properties. Low concentrations of reactive end groups (e.g., a 9000 g.mol-1 oligomer) give a low viscous thermotropic melt (10200 poise at 100 rad.s-1). When cured, a high Tg (>200C) nematic thermoset is obtained that provides an excellent combination of toughness and stiffness.



Representative Micrographs (Polarizing Optical Image).Left image: Microphotograph, LCR-1k 370C melt, (20x) Low viscous nematic threaded Schlieren texture. Right image: Microphotograph, LCR-1k cross-linked 1 h. 370C, (20x) nematic thermoset

APPLICATIONS

The technology has several potential applications:

- Actuator ion - light weight and low power that can handle harsh environments in space and on Earth
- Active control - noise control, and flow management for aircraft and industrial applications

PUBLICATIONS

Patent No: 6,939,940; 7,507,784

More Information

National Aeronautics and Space Administration

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